FOODS FOR SHELTER STORAGE

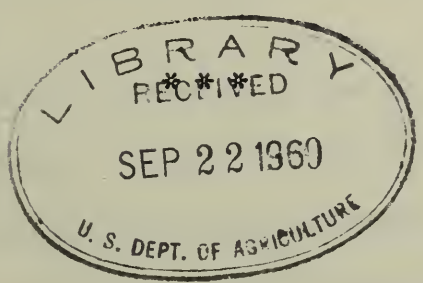
A LITERATURE REVIEW

FOR THE

OFFICE OF CIVIL DEFENSE MOBILIZATION

Final Report

FOODS FOR SHELTER STORAGE
A Literature Review



To

Ralph L. Garrett
Office of Civil and Defense Mobilization
Battle Creek, Michigan

From

J. G. Woodroof
Georgia Experiment Station
University of Georgia
Experiment, Georgia

Contract No. CDM-SR-59-31
Period: 1 January 1959 - 30 January 1960

FOREWORD

This is a summary of a 328 page report consisting of 735 literature abstracts and citations, tables, a complete index, and discussions of foods and containers for shelter storage.

From this review of literature it was shown that at least 162 food products (which may include approximately 2000 individual items) could be satisfactorily stored in emergency shelters at 70°F. for two to three years; 48 products could be held for three to five years; and 27 products for five years or longer. Of those with a storage life of two to three years, seven were unprocessed foods; eight were processed foods requiring cooking; and 147, of which 57 were dried or dehydrated, were foods requiring little or no cooking.

For a more thorough study of this subject, it is suggested that the full report be used, and that many of the original research publications be obtained.

FOODS FOR SHELTER STORAGE

by

J. G. Woodroof

* * *

TABLE OF CONTENTS

SUMMARY

A digest was made of current published and unpublished information of foods for shelter storage for use in the event of national disaster, particularly a nuclear war. General requirements were that the foods be: (a) acceptable for general consumption for a minimum of two years at room temperature; (b) available in sufficient quantity for shelter occupants for a minimum of two weeks; and (c) of such kinds and varieties as to maintain physical and mental stability in people of all ages, and of both sexes.

In the course of this study technical information from 12 countries was studied, interviews were arranged with personnel of the Quartermaster Food and Container Institute, and visits were made to commercial plants manufacturing foods and containers.

Criteria for selecting foods for shelter storage were that they be palatable, stable, nutritious, available, economical, simple to prepare and serve, have an attractive aroma and normal texture, and have little or no waste.

Lists of unprocessed foods, processed foods which require cooking, and processed foods requiring little or no cooking were prepared with acceptability of (a) two to three years; (b) three to five years; and (c) five years or more in storage at room temperature.

Means of improving or extending the shelter life of some foods are: (a) refrigerated storage; (b) use of flavor enhancers; (c) adjusting acidity; (d) freeze-drying; (e) use of in-package desiccants with low moisture foods; (f) compression of dehydrated foods; (g) use of glucose-free dried eggs; and (h) use of surfactants to improve dispersibility of dry whole milk.

Packages for shelter-stored foods must protect them from outside oxygen, moisture, bacteria, molds, dirt, odors, yeasts, insects and rodents. The "built-in" life of the package should exceed that of the product. Good packages, listed in order of preference, were made of tin-plate, flexible materials, aluminum, plastics and glass. Some good containers were also made of fiber.

Temperature is the most important variable condition in the storage of foods, with relative humidity next in importance. Changes which normally occur in foods at a certain rate at 32° are doubled at 50°, increased 4 times at 68°, 8 times at 86°, 16 times at 104° and 32 times at 122°. All forms of mold are effectively controlled by maintaining a relative humidity of 60 percent or lower.

Whether to rotate foods frequently or store them to destruction depends upon the kind of food, the management of the shelter, and whether or not second quality foods may be used in some other manner. Assuming that the quality is maintained, the estimated cost of handling and storage of common items such as apple jelly would equal the purchase

price in six years in common storage and in five years if held under refrigeration. More expensive meat items could be stored for as long as 15 years for the purchase price. Bulky products could be stored for only two or three years for the purchase price.

In general, the nutritive value and palatability of foods are gradually lost in storage along with changes in normal texture, color, aroma and flavor.

The loss of ascorbic acid and thiamin in foods is more rapid at high than low temperatures. Vitamin A, carotene, riboflavin and niacin are more stable. Ascorbic acid is lost more rapidly from vegetables than from fruits.

Insects and rodents are problems where foods are exposed or the odor of foods prevail. Since they attack many items other than foods, it is doubly necessary that they be controlled. Methods of control consist of: (a) the use of metal, glass or other protective packaging; (b) scrupulous cleanliness and sanitation; (c) temperatures of 48° or lower (this does not control rodents); (d) mechanical electric traps; (e) special poison baits or fumigants; and (f) irradiation of unprocessed foods, containers and certain equipment.

Foods available for shelter storage included canned meats and meat products, seafood and seafood products, canned vegetables, canned fruits, canned juices, candy and confectionery items, bakery products and dehydrated foods. Suitable foods may be selected from these and menus for serving prepared.

Before an entirely satisfactory program of foods for shelter storage can be realized, additional studies should be made. These include a search for a wider variety of convenience foods, particularly "heat-and-eat" canned foods; "chill-and-serve" juices, fruits, salads and desserts; "add-water-only" dehydrated foods such as milk and milk products; and "eat-from-the-package" confectionery type foods. These foods are especially suitable for shelters, in that little or no seasoning or cooking is required, and there is a minimum of preparation and no left-overs.

There is further need for more one-dish meals which should be highly acceptable and be supplied with the minimum daily requirements of carbohydrates, proteins, fats, minerals and vitamins. A special study should be made of methods for preparing and serving foods in shelters of various sizes. This includes the best procedure for opening containers, disposing of empty containers, preparing and serving the food, disposal of garbage or left-over foods and means of handling special dietary problems.

Additional research is also needed in the development of better flexible packages, rustproof tin cans, rigid aluminum containers and master containers for stored foods.

INTRODUCTION

This study of Foods for Shelter Storage is a part of a program of preparedness in the event of national disaster--particularly that of a nuclear war. When disaster occurs, food and drink may be means of providing not only body energy, but of relaxing nerves, diverting attention from worries and fears, and providing a communal attitude. The elimination of fear of hunger and thirst will go far toward alleviating other fears. Other than providing fresh air to breathe, and heat (or cooling) for body comfort, food and drink are the most important requirements for survival.

This is a review of literature on the storage life of various products and the effects of the methods of processing, manner of packaging, moisture content, and chemical and physical changes on the palatability and nutritive value as influenced by temperature and time of storage.

This report consists of an appraisal of the available published data on the stability of foods for shelter storage and other information gathered throughout the contract period, including conclusions and recommendations of the contractor, criteria for selecting foods for shelter storage and needs for further study. Thirteen compendiums on specific subjects relating to food storage are included.

Food for shelter storage will vary from area to area, depending upon the availability of food and habits of the people. However, the poor stability of many favorite foods render them unsuitable for storage, and a great deal of tolerance may be necessary on the part of occupants. Rigid supervision and cooperation will also be required for best utilization and distribution of limited food supplies.

The amount of food stored in shelters of various sizes is directly related to the anticipated occupancy and the estimated time of confinement. Current proposals are that those occupying a shelter will be completely confined for 14 days, with food served at least three times daily. Prepared menus are to be followed, except for those requiring special foods due to age, injury or illness.

Food in home shelters is an extension of the family pantry; that in shelters of hospitals, schools, and county, state and federal buildings is a supplement to the supplies normally maintained in the present eating places in these buildings; while food stockpiled in large subterranean areas requires special facilities for storage, inspection, preparation, serving and disposal of unused food and containers.

The rotation of foods in shelters depends upon the type of shelter, location and type of foods stored. By reference to

pages 6 through 16 , a list of foods may be made that need to be replaced at fairly definite times--after 2-3, 3-5 and 5 or more years. It is suggested that foods with similar shelter life be packaged together and marked with the expiration date. In this way, replacements may be made at the time of regular food inspections. A greater variety of foods may be selected if low temperature storage is available.

Foods are at their optimum aroma, flavor, texture and nutritional quality at the time they are harvested, cured or processed. Undesirable changes begin immediately and continue until the product becomes unacceptable. This period varies from a few hours, as with certain cooked foods, to several decades, as with dried grains. Among the treatments used to prolong the period that foods remain useable are: drying, salting, heating, chilling, packaging, removing air, fumigating; and using preservatives such as antioxidants, mold inhibitors, insecticides, fungicides, reducing agents, sugars and spices.

Foods, as they are transported, sold and stored, have received more than one of the above treatments. Furthermore, each of the treatments may be applied at varying degrees. For these reasons the storage period of foods is extremely variable. The storage period of certain foods has been found to be 27 years or more. Therefore, it is entirely practical to stockpile selected foods, under specified conditions, to be used five or 10 years later.

Following these discussions are narrative and tabular abstracts with literature references under six headings. These are: (a) unprocessed foods; (b) processed foods which require cooking; (c) processed foods requiring little or no cooking; (d) irradiated foods; (e) food containers; and (f) nutritional and palatability factors.

In the tables and narratives all temperatures are given in Fahrenheit, and humidities are given as percent saturation.

A suggested method of using this report is to: (a) read the summary to get the general approach to method of presentation and analysis of results; (b) read one or more of the compendiums on the particular phase of the subject being studied; (c) review abstracts in the appendix on the specific subject to determine experimental results; and (d) through the literature references obtain and study several original published reports on the particular subject under study.

COMPENDIUMS

A brief compilation of the results of this study is included in the following narratives.

Source of Information for this Report

This report is a brief compilation of the present knowledge on the Stability of Foods for Shelter Storage. The information was obtained from (a) reviews of literature; (b) studies of unpublished reports of research conducted by the Georgia Experiment Station and by the Quartermaster Food and Container Institute for the past 10 years; and (c) interviews with personnel and visits to commercial plants manufacturing foods and containers.

The review of literature consisted of studying bulletins, documents and reports from (a) NATO and other international organizations, and several agencies of the United States Government; (b) state experiment stations and universities; and (c) technical journals published in the United States, Canada, Great Britain, France, Italy, Australia, India, USSR, Czechoslovakia, Germany, Venezuela and Argentina.

The abstracts and references included in this report were selected because they contained information directly related to the stability of stored foods and their containers.

In most cases the original manuscript was obtained for study; however, in a few cases abstracts were used. The number of manuscripts studied fully doubled the number that were abstracted for use. While the report may appear long, a real effort was made to keep it as short as possible to cover the subject.

Criteria for Selecting Foods for Shelter Storage

In selecting foods for shelter storage, certain criteria are required. The following are listed in the approximate order of importance:

The foods must be palatable. It is essential that they be acceptable and relished by people of different ages, sex, physical condition and emotional stress.

The foods must be nutritious. While energy and satisfaction of hunger are the first requirements, the diet should be well balanced in proteins, fats, carbohydrates, vitamins and minerals. Normal nutrition is desired for occupants of shelters for a minimum of two weeks.

They must be available and economical. In as far as possible, familiar foods that are generally eaten in an area should be stored in shelters. When disaster occurs the "change-over" from normal eating habits to stored foods should be as simple as possible. Specialties may be used only for variety in the diet.

Foods must have a long shelter life. Other conditions being equal, preference is given to foods with the longest shelter life. Some items may be stored indefinitely and others for specific lengths of time, i.e., 1, 3, 5 or 10 years.

Foods must be simple to prepare and serve. In as far as possible, one-dish meals--soups, stews, hash, meat-vegetable mixes, with the addition of fruits and fruit juices, vegetables and vegetable juices and milk, to complete the meal--that can be served directly from containers should be used. Preference goes to foods that do not require heating.

Minimum of garbage is preferable. Favor is given to foods that are completely edible in disposable containers. Empty containers should be light, compressible and free from hazards.

The food should have a pleasant odor. In confined areas the odor of a food may determine whether or not it will be eaten. With other factors equal the food with the most pleasant odor should be used; and in some cases appetite stimulating odors might be used.

Foods should have normal texture. While milk, soups and juices might be nutritionally adequate, a reasonable amount of "chewy" foods should be used. This is to add pleasure to eating, and to add variety to the meals.

Foods with Shelter Life of Two to Three Years at 70°F.

UNPROCESSED FOODS

Beans and Peas, Dried

- Beans, 5-10% moisture
- Peas

Cereal Grains

- Barley
- Corn, shelled
- Rice, brown or hulled
  rough or unhulled
  milled, parboiled
- Wheat, 6-12% moisture

Nuts

- Walnuts, black, shelled

PROCESSED FOODS WHICH REQUIRE COOKING

Bakery Mixes

Bread, quick
yeast, w/6% moisture flour
Cake, 3% moisture
Devil's Food w/8.8% moisture flour
yellow/2.8 to 2.1% moisture flour

Flour and Meal

Cereals, barley, wheat, oats and their products
Flour, white
6-12% moisture
Meal, corn, 6-12% moisture
degerminated
soya
Wheat base

PROCESSED FOODS REQUIRING LITTLE OR NO COOKING

Canned, Bottled or Packaged

Bakery Products

Biscuits, army-type, 100-hr. shortening
milk-type, hydrogenated shortening
Bread, chocolate, nut
white
Cake, fruit
fruit, steamed
pound
pudding
Cookie, sandwich
Crackers, soda, salted

Beverages

Beverage base, liquid, Type II
Coffee, roasted, ground
soluble
Tea, soluble
Water, canned
Wine, Rhine Riesling

Fats and Oils

Lard, antioxidant treated
Margarine

Fruits and Fruit Juices

Apricots
Cherries, maraschino
Fruit cocktail
salad
Orange juice, single strength
slices
Papaya juice
Pears
Peaches
Plums, gages
yellow

Meats and Fish

Bacon, sliced
prefried
Beef with cereals, gravy or vegetables
Beef, canned
corned
Beefsteaks, onions
Beef products, tomato sauce
Beef, vegetables with gravy
Chicken
Chicken, solid pack
Chicken and noodles
vegetables
Chili con carne
Ham chunks
chopped, and eggs
spiced
Hamburger, chopped onion
Meat and beans with tomato
Meat, ground and spaghetti
tomato sauce
noodles
stew and vegetables
Pork, canned alone, with gravy, or with vegetables
Pork and apple sauce
Pork chops
Pork, luncheon meat
Pork, sausage
patties
prefried

Pork steaks
Poultry items, alone, with gravy, cereals or vegetables
Seafood, cod, cod for babies, crab, haddock, pollock, shrimp
salmon, lobster

Milk and Milk Products

Cheese, processed
Cheddar
American
Milk, condensed, sweetened
evaporated
whole, sterilized (Winger process)

Sandwich Spreads

Caviar
Cheese spread
Jam, apricot
grape
peach
pineapple
Peanut butter

Soups

Assorted
Ready-to-serve
Chicken

Vegetables and Vegetable Juices

Beans, tomato sauce
Celery
Corn, cream style
whole grain
Parsnips
Potatoes, sweet
white
Pork and beans, tomato sauce
Tomatoes
juice, single strength
concentrate
paste
Vegetables, assorted

Miscellaneous

Cigarettes
Food flavoring, ice cream assortment
extracts, maple, vanilla and vanilla tablets, imitation
Olives, relishes
Salad, dressing
Sauces, catsup, chili, hot, kitchen, meat, soy and Worcestershire
Vinegar, cider

Confections, Cocoa Products and Nuts

Candy, hard
starch jelly

Chocolate, beverage syrup
crumb
sweet bars, discs

Cocoa
beverage discs
powder

Gum, chewing, sugar coated

Nuts, macadamia, roasted

Dehydrated or Evaporated Foods

Cereals

Assorted
Premixed

Condiments

Horseradish
Monosodium glutamate
Salt, garlic
table
Spices and herbs

Crystallized Juices and Beverages

Beverage bases, synthetic fruit flavors
Grapefruit
Grape
Orange

Crystallized Sugar

Sugar, confectioners
granulated

Dessert Mixes

Coconut, sweetened prepared
Ice cream mix
Gelatin, plain
Meringue powder
Pudding, starch base

Dried Eggs

Eggs, albumen, glucose-free
whole, glucose-free
yolks, glucose-free

Dried Fruits

Apples
Applesauce, instant

Meat, Poultry and Fish

Hamburger
Meat bars
Mutton mince

Milk and Milk Products

Butter
dry, blended
Cheese, bakers, 5% moisture
Cream, coffee-type
Milk, instant, nonfat
skim
whole

Soups

Chicken, noodle
Onion
cream of, precooked
Pea, green
precooked
Potato, cream of
precooked
Soup and gravy base

Starchy Products

Corn starch
Macaroni products (macaroni, vermicelli, spaghetti)
Noodles
Spaghetti
Tapioca

Dry Honey and Syrup

Honey

Vegetables

Beans, green
Cabbage
3.0% moisture
Carrots, 4.0-5.0% moisture
Corn, sweet, yellow
Corn
5.7% moisture
Onions
Peas
Peppers
Potatoes, white
7.75% moisture
Tomato juice powder

Miscellaneous

Baking powder
soda
Yeast, mineral food

Foods with Shelter Life of Three to Five Years at 70°F.

UNPROCESSED FOODS

Cereals

Corn, shelled
Rice, brown or hulled
rough or unhulled
Wheat

PROCESSED FOODS WHICH REQUIRE COOKING

Flour and Meal

Flour, white, 13-14% moisture

PROCESSED FOODS REQUIRING LITTLE OR NO COOKING

Canned, Bottled or Packaged

Bakery Products

Cake, fruit steamed
pound

Beverages

Water, canned
Wine, Rhine Riesling

Meat Products

Beans/frankfurters in tomato sauce
Beef/cereals, gravy or vegetables
Beef, corned
gravy, vegetables
Chili con carne
Meat, ground and spaghetti/tomato sauce
Pork, sausage patties
Poultry items alone, with gravy, cereals or vegetables
Seafood, cod, and cod for babies
crab
haddock
lobster
pollock, flaked
shrimp

Milk and Milk Products

Cheese, American processed
Milk, condensed, sweetened unsterilized
whole sterilized (Winger process)

Sandwich Spreads

Jam, apricot
Peanut butter
fortified

Soups

Assorted
Chicken
Ready-to-serve

Vegetables and Vegetable Juices

Tomatoes
Vegetables, assorted

Miscellaneous

Food flavoring, maple, vanilla extracts and vanilla tablets, imitation

Dehydrated or Evaporated

Condiments

Monosodium glutamate
Salt, garlic
table

Crystallized Sugars

Confectioners
Granulated

Dried Eggs

Eggs, albumen, glucose-free
whole, glucose-free

Milk and Milk Products

Cream, coffee-type
Cheese, bakers, powdered
5.0% or less moisture
Milk, nonfat solids
whole
Whey, powder

Starchy Products

Spaghetti

Syrup and Honey

Honey, dehydrated

Vegetables

Beans, green
Corn
Peas, 2.0-4.5% moisture
Potatoes

Miscellaneous

Baking powders
soda
Yeast, mineral food

Foods with Shelter Life of Five Years or More at 70°F.

UNPROCESSED FOODS

Cereals

Corn, shelled
Rice, brown or hulled
rough or unhulled
Wheat

PROCESSED FOODS WHICH REQUIRE COOKING

Flour and Meal

Flour, white

PROCESSED FOODS REQUIRING LITTLE OR NO COOKING

Canned, Bottled or Packaged

Beverages

Water, canned
Wine

Meat Products

Chili con carne
Meat, ground and spaghetti/tomato sauce
Pork sausage patties

Milk and Milk Products

Milk, condensed, sweetened, unsterilized
whole, sterilized (Winger process)

Vegetables

Tomatoes

Miscellaneous

Food flavoring, extracts, imitation vanilla and maple
tablets, imitation vanilla

Dehydrated or Evaporated

Condiments

Monosodium glutamate
Salt, table

Crystallized

Sugar, confectioners
granulated

Eggs

Albumen, glucose-free

Milk and Milk Products

Cheese, bakers/5% or less moisture
Cream, coffee-type
Whey powder

Vegetables

Potatoes

Starchy Products

Spaghetti

Syrup and Honey

Honey, dehydrated

Miscellaneous

Baking powder
soda
Yeast, mineral foods

Means of Improving or Extending the Shelter Life of Some Foods

By utilizing improved methods of processing, packaging and storage, (a) the shelter life of some of the foods listed on pages 6 through 16 may be extended; (b) the quality of some may be improved; or (c) other foods may be added to the list. Some of the nine suggested improvements are in extensive use while others are in the experimental stage. References are in the appendix.

Refrigerated Storage. Temperature is the most important variable condition in the storage of foods; and foods have an increased shelter life at reduced storage temperature. This is true whether they are unprocessed, canned or dehydrated.

Storing processed foods at 0° or below is an excellent method of preservation for two to ten years. Freezing results in the formation of ice in the tissue, and tends to break down the texture of most processed foods. This action tenderizes meats but also softens fruits and vegetables. In the case of tomatoes, summer squash and other vegetables with very high moisture content, the product becomes "watery"; and the starch in a few products curdles, as in cooked potatoes, producing a spongy texture.

High storage temperatures (100° or above) damage foods by causing an "overcooked" color, aroma, texture and flavor. The rate of deteriorative breakdown varies with the food item. For this reason only foods with similar life expectancy should be packaged

together. Further information on the effect of temperature on foods in storage will be found in the compendium, The Effect of Temperature and Relative Humidity on Storage, page 22.

Flavor Enhancers. These are added to certain foods to improve the flavor only, and include spices, monosodium glutamate (MSG) and even salt. MSG enhances the aroma and flavor of fresh, canned, dehydrated and frozen foods, representing meats, vegetables, seafoods and specialty items. Preferences for glutamate-treated foods are based on general flavor qualities, such as "impoved," "finer," "sweeter," "full rounded," and "minimum of raw."

MSG enhances flavors in foods by (a) its blending effect on flavors; (b) supressing unpleasant factors, such as rawness in cereals, and sourness or bitterness in other foods; and (c) its salivation effect on "feeling" factors and aftertaste in the mouth.

Acidity. In general the higher the acidity (the lower the pH) of a food product the less processing is required, the more stable the colors and flavors, and greater the corrosion of the metal containers. Canned fruits with a low pH value require less processing than vegetables and meats with a high pH. Low pH in cream fillings and related products aids in controlling bacteria. Increasing the acidity of canned or dehydrated fruits aids in the retention of vitamins, flavor or color; and iodine is better retained in salt with a low pH.

Freeze-drying. This is a method of removing moisture from foods in the frozen state so that they are light and porous and therefore rehydrate more completely and quickly to more normal texture. Among the foods dried in this manner are chicken, beef, shrimp, potatoes, milk, coffee and citrus juices. Vacuum or inert-gas packing and in-package desiccant are necessary for maximum stability by maintaining moisture levels at 2.0 percent or lower.

Dehydration of foods from the frozen state is proving successful for meats, fruits, vegetables and prepared foods. The moisture level of such foods is low enough to assure product stability without refrigeration. The products retain their porous structure permitting rapid reconstitution. Freeze-dried meats are easily prepared and highly acceptable; vacuum dehydrated fruit juices form a porous foam-like product which is crushed to reduce volume in packaging.

Most foods dehydrated from the frozen state are especially suitable for shelter storage and are becoming available commercially. Those in powder form are compressed, and most of them may be reconstituted "instantly" with water, at 185°. The following 36 foods are being processed to a very low moisture content by accelerated freeze-dehydration:

Applesauce, precooked	Onions, precooked
Apricots	Orange juice
Bacon, precooked	Pea soup, precooked
Beef stew, precooked	Peaches
Cabbage	Pork chops, precooked
Cheddar cheese	Potatoes, precooked
Cream	Pudding, butterscotch
Fish sticks	Pudding, chocolate
Fruit cocktail	Prunes
Grape juice	Roast beef, precooked
Grapefruit juice	Shrimp, precooked
Green peas, precooked	Sliced chicken, precooked
Green peppers, precooked	Snap beans, precooked
Ham, sliced, precooked	Spaghetti and meat balls, precooked
Macaroni, precooked	Spanish rice mix, precooked
Meat loaf, precooked	Sweet potatoes, diced or pureed
Milk, nonfat	Tomato juice, precooked
Oatmeal, precooked	Tomato paste, precooked

In package desiccants with dehydrated foods. These are used to further reduce the moisture content of already dried foods, after packaging. The use of desiccants is to extend the shelter life of foods by (a) protecting dehydrated vegetables against non-enzymatic browning; (b) preventing off-flavor development in powdered orange juice; (c) protecting vegetables and fruit powders from caking and loss of sulfite and ascorbic acid; and (d) retaining color in dehydrated beets and other products.

Calcium oxide (lime) is generally the preferred desiccant because of its high water capacity at low relative humidities of one to five percent; however, silica gel, alumina and montmorillonite (Desiccite) are used successfully. Desiccants in small sift-proof bags, usually paper-coated jean cloth or stretchable "Promset 831X", are hermetically sealed in containers with the product. Enough of the chemical is used to absorb all free residual moisture in the package. One packet of the desiccant placed near the center of packages of two pounds of food or less is sufficient; however, three or more packets placed in widely separated locations of bulk packages are needed. The rate of moisture removal by desiccants is increased 2-3 fold per each 18° rise in temperature.

Compression of dehydrated foods. This operation, requiring equipment designed for the particular product, reduces the space occupied by foods, reduces the amount of air in the package, and kills insects at pressures of 500 pounds/square inch or greater. Compression is satisfactory for meats, diced beets, shredded cabbage, diced carrots, flaked onions, apple nuggets, cranberries and apricot halves, for which volume reduction ranged from 53 to 83 percent. Success depends upon several factors including breakage and production of fines, coherence, density economically attainable, and time required for rehydration. Compression does not appreciably alter the shelter life of foods.

Glucose-free dried eggs. Dried whole eggs with the sugars removed by treatment with enzymes are simpler to rehydrate and prepare for eating than acidified dried eggs which require neutralizing with soda before cooking. Glucose-free eggs at 2.0 percent moisture

have increased shelter life when inert gas-packed. Dried glucose-free egg whites are even more stable than the yolks or whole egg powders.

Dispersibility of dry milk. The use of surfactants has greatly improved the dispersibility of dry whole milk. The most suitable products for this purpose have been those containing the polyoxyethylene molecule of which polyoxyethylene sorbitan mono-oleate (Tween 81) is an example. Dry whole milk disperses with greater difficulty than nonfat solids due to the fat content. Whole dry milk disperses quite readily in water at 110° to 120°. An attempt has been made to increase the percentage of crystalline lactose in whole dried milk, similar to the process used to produce instant dry whey powder. This later process has been used successfully for production of nonfat milk solids.

Premixed cereal bars and discs. Sugared cereals premixed in various combinations and compressed into bars or discs may be eaten out of hand, crumbled with milk, or rehydrated in hot water or milk. Bars compressed with small amounts of added water are firm and have three times the shelter life of bars with glycerine added for increased rigidity.

Packaging Foods For Shelter Storage

The shelter life of foods is determined to a great extent by the kind and manner of packaging. The function of packages is to act as a barrier to outside oxygen, moisture, bacteria, mold, dirt, odors, yeasts, insects and rodents. Packages may also influence the action of enzymes, metallic catalysis, hydrolysis, reduction and changes in pH. In general the "life" of a package is about equal to that of the products, and as the latter are improved new qualities are "built-in" the package.

A package is intended to protect the product from physical damage and chemical deterioration. In general, (a) unprocessed foods are packed in multiwall, flexible, semi-moistureproof bags or cartons; (b) liquid-packed processed foods are in tin cans, glass bottles with metal caps, or aluminum cans; and (c) dehydrated foods are packed in airtight, flexible packages of laminated materials, sometimes in vacuum or with inert gas. The "built-in" storage life of a package for a particular product is intended to be slightly longer than that of the product, which is usually less than two years at shelter storage conditions. For longer periods of storage packages that are more resistant to moisture, temperature, oxidation and time are needed. These include multiwall bags, tin cans, bottle caps, aluminum cans and laminated packaging materials.

The improvements in packaging are almost limitless provided the quality of the product and costs justify them. Improvements include corrosion resistance inside and outside of tin or aluminum cans; closing containers without air; insectproofing; moisture-resistance; capacity to hold vacuum and/or gas in flexible packages; bottles and cans that are easier to open and empty; and packages that are easily and quickly disposable.

Corrosion of containers is the gradual decay or deterioration of materials due to chemical or microbiological agents, and is commonly used in reference to metals. It is caused by reactions between the container surface and oxygen of the air, and is catalyzed by moisture and

certain chemical agents. The best control of corrosion is to store containers in a cool (70° or lower), dry (50 percent relative humidity or lower) atmosphere, without acid or other corrosive fumes. Weakening or breakdown of fiber cases, barrels, or boxes is caused by high humidity of the air and results in "fatigue" of packages.

Protection against moisture. The package should be protected from moisture and this in turn protects the product. Especially coated tins, aluminum or glass containers are preferred, though laminated flexible packages are good. Vapor transmission must be prevented, since a change in moisture content of certain foods causes caking, staling, browning and loss of palatability. Mildew or molding on containers or foods are further ill effects of high moisture. If the relative humidity of the room cannot be controlled below 70 percent a fungus inhibitor should be used. Such compounds are (a) phenolics, (b) heavy-metal derivatives, (c) aromatic compounds and (d) quaternary ammonium compounds.

Tin cans. Tin cans are preferable to other containers from the standpoint of availability in many sizes, cost, equipment for using, low damage rate and long storage life. However, for many products cans with special inside coatings are needed, and to prevent corrosion outside coatings are needed as well.

Most canned fruits, vegetables and meats are in cans either 2 1/8", 2 11/16", 3" or 6 3/16" in diameter. The height ranges from 1 9/16" to 7", with 4 11/16" being most common. The cans are packed either 12, 24, 36, 48, 72 or 96 to the case and either one, two or four tiers high. While most cans are round, others are square or oblong. The contents vary from three ounces to six pounds and 10 ounces, and from 2 3/4 to 48 fluid ounces.

Glass containers. These are excellent for preserving foods, are resistant to corrosion and have other valuable qualities, but should be used only in a limited way for shelter storage due to the hazards of breakage. The caps of glass containers may be coated for resistance to moisture from without, and acids from within. The size and shape of glass containers for foods are less standardized than those of tin.

Flexible packages. Flexible, laminated packages are being improved constantly and should be used wherever possible in shelter storage of foods. They are especially suitable for dehydrated or compressed foods, are available in any desirable size, non-breakable, highly resistant to corrosion and are easily disposable after use. However, some flexible packaging materials, when subjected to extreme temperatures, become brittle, dialate or warp, thus reducing the protection of the contents. Satisfactory pouches for nitrogen gas or vacuum packaging may be made of either mylar-aluminum foil-saran, paper-polyethylene-aluminum foil-polyethylene or mylar-aluminum foil-vinyl. Mylar supplies the outer durable protective film; aluminum foil supplies the moisture and oxygen barrier; and saran, polyethylene or vinyl film supplies the heat sealing properties. Flexible packages must be resistant to diffusion of grease from the inside or contamination from the outside. Those for greasy foods should be treated with an antioxidant such as BHA, BHT or NDGA. These materials may be incorporated into the board when made or used as a coating on the inner surface of flexible packages. Some flexible packages have a shelf life of five years at 100°.

Plastic packages. While plastic (polyethylene, polystyrene, vinyl) food containers are not suitable for heat processing, they have many advantages for specialized uses. They may be pressurized, or vacuumized; are cheaper than tin, glass or aluminum; do not break, dent, rust or leak; are available in many sizes, shapes and colors; are highly resistant to acids, alkalis and foreign odors; and may be stored for one to five years or reused many times.

Fiber drums. In recent years there has been a growing demand for fiber drums or barrels. These are normally straight or convolute wound rather than spiral. These drums are suprisingly strong and tough and are widely used for dry or liquid products. They are made in any size, and are moistureproofed by lining with wax, aluminum foil or polyethylene. The high rigidity, moisture and breakage resistance and general adaptability for handling and storage render these containers well suited for storage in large shelters.

Fiber tubs are similar to fiber drums but are smaller. They might be quite suitable for dry products stored in small shelters.

Optimum size packages. There are no standard sizes of containers for foods, though the United States Tariff Commission recognizes more than 200 (there are 10 kinds of packages for wheat flour alone). The most realistic size packages for foods in shelters are those which experience has proven to be most acceptable in commercial channels. The individual containers are either consumer-size, institutional-size or bulk-size and the cases are made to fit. Cases for cans, bottles or flexible packages vary widely according to size of the units and a few general specifications should be approached.

Packing cases. Packing cases protect the individual packages from crushing, moisture and "fatigue." They may be round (metal or fiber barrels), rectangular or flexible. Individual units may be assembled in cartons and these in turn packed in "master cases." The latter will vary with the type of shelter--home, community, public--and with the type of food--bottled, canned or dehydrated. Since the shelter life of the unit packages depend greatly on the protection afforded by the master cases, the latter should be of highly moisture resisting materials. These include specially treated corrugated boards, asphalt, aluminum foil or film laminated boards, and metal or painted materials.

Stacking in warehouses. Pallets for stacking in warehouses vary considerably. The most nearly standard pallet is 40" x 48". A pallet of this size will fit five cases 16" x 24" when three cases are laid parallel and two cases are laid across the end in the opposite direction.

Sometimes it is desirable to place a pallet in a master container, in which case the latter would be made of wood, metal or heavy fiber board with inside dimensions of 42" x 52". The

height of the master container should be 20" to accomodate a pallet load of 10 cases, two tiers, of packaged food. Master containers for foods for shelters in the home, schools, hospitals or public buildings must be designed around the menus selected for these locations.

The Effect of Temperature and Relative Humidity on Storage

Low temperature and controlled humidity prolong the shelter life of practically all foods, even though they have been heat processed, dehydrated to a safe moisture level or irradiated. This was shown by data on pages 16 through 19, and was emphasized under "Means of Improving or Extending the Shelter Life of Some Foods." High storage temperature, dampness and insect infestation are the major causes of deterioration of processed foods and their packages.

Temperature is the most important variable condition in the storage of foods, and relative humidity is next in importance. The beneficial effects of reduced temperatures have been recognized for a long time, but chemical reactions due to high temperatures are complicated and not fully understood. The principle is that as the temperature rises, the speed of reactions increases. Generally, the rate at which chemical reactions occur doubles with each 18° rise in temperature; but actually the rate of change of some of the reactions that alter the flavor, color, texture and nutritive value of processed foods may increase as much as six times. Chemical reactions which normally occur at a certain rate at 32° are doubled at 50°, increased four times at 68°, eight times at 86°, 16 times at 104° and 32 times at 122°.

There is a relationship between acceptability and storage deterioration, and evidence that loss of appetite is also related to deteriorative changes in foods.

Temperature is a governing factor in microbiological activity which sometimes occurs in processed foods as well as in internal corrosion of cans and metal lids on glass jars. Certain highly acid and pigmented fruits and berries corrode the interiors of tin or aluminum containers causing loss of vacuum, hydrogen swells and perforations. The products of the corrosive action of sulfur in proteins of meat and certain vegetables may cause dark discoloration of canned food.

Insects are effectively controlled in grains, nuts, flour, dried raisins, prunes, figs, dates, peaches and apricots by storage at 48° or lower. Mold growth on dried fruit, nuts and cereals is prevented at relative humidities of 60 percent and lower; gain in weight and sugaring of raisins and figs occurs at higher relative humidities. The shelf life of dried products and dry mixes is extended three times by reducing the moisture content to one-third.

The feasability of providing refrigerated space for storage of foods in shelters will need to be decided upon in individual cases. The decision is whether the cost of refrigeration is greater than the lack of it. It is recommended that wherever possible foods be stored at 48° at least, and for as much of the storage period as possible.

Estimated Cost of Storing Foods in Shelters

Throughout this study references are made to the advantages of refrigerated storage as a means of controlling insects and extending the shelter life of both products and packages. Costs are divided into "storage" and "handling," and are based on density or package displacement, varying floor loads and pile heights. Since the cost of handling is "fixed," the relative rate decreases with the length of storage. Factors affecting price are value of the product, susceptibility to deterioration, size of lots stored, labor availability and costs, efficient use of space and effect on other stored products.

Costs for storing food in refrigerated warehouses appear to be more standardized than in common warehouses. For example, rates in refrigerated warehouses are based on weights; while rates of some products in common warehouses are by the case, some by cubical contents and others by density. Many warehouses rent space irrespective of the products stored; one quotation was "20¢ per square foot per month for non-refrigerated space, 40¢ per square foot per month for cooler space, and 10¢ per hundredweight for handling in and out." Other warehousemen prefer to negotiate rates for long-term storage, which would be much lower than day-to-day turn-over products. Another warehouseman quoted "2½¢ storage per month per case and 4¢ per case for handling in common storage."

It was found in the Chicago area that charges for handling refrigerated storage were slightly higher, being about twice that for storing in non-refrigerated space. It appeared that the overall cost of commercial storage under refrigeration (32°-36°) was about 30 percent higher than storage at room temperature (70°). The average rates per cwt. for handling in non-refrigerated space were 19.8¢ and for storage, 6.9¢ per month. Commercial warehouses perform other services, such as sorting, transferring and marking packages, for which extra charges are made.

The cost of refrigerated storage varied with the location and weather. For example, the cost per cwt. of storing dried fruit for two years in Atlanta was $3.85, and in Kansas City was $2.79. Confections were stored in Atlanta for $6.37, in Boston for $4.33, and in St. Louis for $7.50. The cost also varied with the commodity. The cost per cwt. for two years' storage in Kansas City was $2.53 for nut meats and rice; $3.06 for canned

fruits, fruit juices, milk products, cheese and vegetables; $3.75 for canned meats; $2.79 for canned evaporated milk; $4.29 for dried eggs; and $2.79 for dried fruit. Following is an Estimated Cost of Refrigerated Storage of Foods.

Space	Refrigerating unit and fan	Available refrigeration per hour	K.W.H. cost	Temperature	Cost at 2¢ per K.W. per year
cu. ft.	h.p.	B.T.U.		°F.	
10	1/6	1,000	.25	70	38.00
				65	40.00
				35	50.00
100	1/2	3,000	.50	70	62.00
				65	65.00
				35	75.00
1,000	1 1/2	12,000	1.50	70	175.00
				65	185.00
				35	200.00
10,000	7 1/2	62,000	7.50	70	890.00
				65	925.00
				35	1,000.00

The cost of storing foods in shelters also depends on the size, temperature, humidity and location of the space; and on power rates, type of construction and heat losses while in operation. The estimated costs shown above are based on three service calls per year, with very little materials or refrigerant replacement. The costs will probably increase after the third year due to leaks, parts replacement and general inefficiency of equipment operation.

Cost of frequent replacement of foods as compared with storage to destruction. As the length of storage period increases, the costs increase and the quality of the product decreases. Assuming that the quality is retained, the estimated cost of handling and storage of 16-ounce jars of apple jelly would equal the purchase price in six years when held in common storage, and in five years if held under refrigeration. The cost of handling and storing No. 1 cans of tomato soup will equal the purchase price in seven years of common storage, while Brunswick stew in 24-ounce cans may be stored for 20 years under common refrigeration and 14 years under refrigerated storage for the purchase price.

The criteria for determining the realistic storage period for foods is the stability of the individual products. To retain the maximum acceptability some foods should be rotated after 2-3 years, 3-5 years and others after 5 years. Lists of foods in these categories are shown on pages 6 through 16.

Along with gradual losses in normal texture, color, aroma and flavor in stored foods, there are losses also in palatability and vitamins, and changes in fats, proteins and carbohydrates. These changes occur in foods whether they are processed or not, and irregardless of the method by which they are processed. In general the nutritive value and palatability of a food changes at about the same rate. Variables influencing the rate of change in foods include nature of the particular food, the moisture content and pH values, stability of individual vitamins, the method of packaging and the temperature and time of storage.

The influence of temperature on the stability of the quality of stored foods has already been emphasized, and the influence of storage on the individual vitamins in particular products is found in the abstracts in the appendix, together with remarks on specific palatability changes in stored foods.

If canned products are stored in warehouses where temperatures range from 70° to 90°, lowering the average temperature by as little as 5° over a period of three to six months may bring about definite savings of ascorbic acid, thiamin, desirable flavor and often texture characteristics.

Vitamin retention in foods is dependent on method of processing, storage time and temperature, exposure to oxygen and the chemical composition of the food. Raw products high in specific vitamins remain significant sources after processing. Fat soluble vitamins are least affected by processing methods, while serious losses of water soluble vitamins may occur. Ascorbic acid and thiamin are gradually lost with time in storage, and are adversely affected by increased temperatures. Ascorbic acid in fruits decreases to a greater extent than in vegetables at a given storage temperature, due to their greater acidity and higher sugar content. Carotene, niacin and riboflavin values of canned fruits and vegetables change to a small degree during storage. However, riboflavin retention is slightly better at lower temperatures.

The influence of storage conditions on vitamins in canned seafoods has been investigated less extensively; however, retention in salmon was found to follow the same trend as for other foods.

Riboflavin, niacin and pantothenic acid values of canned meat are not affected during one years' storage at 45° to 98°, but thiamin content is influenced by storage time and temperature. Therefore, for canned meats which contain important amounts of thiamin, cool storage (45°) is important.

The retention of ascorbic acid, thiamin and carotene in pears, orange juice and tomatoes in every instance was as good as or greater than when these products were stored in commercial warehouses as compared to a constant temperature of 80°.

Riboflavin, niacin and vitamins D and E appear to be little affected during storage; but vitamin A and thiamin are gradually lost, and there may be serious destruction of ascorbic acid.

Foods lose vitamin A, thiamin and ascorbic acid during drying, especially if the process is prolonged as with sun drying. The use of sulfur dioxide is particularly destructive of thiamin. There is no appreciable loss of riboflavin in dried or evaporated milk, and little loss of vitamins D and E and niacin in any foods due to drying.

Most vitamin losses in canning are due to oxidation. Therefore, canned foods for storage should be processed in the containers after excluding as much air as possible. Ascorbic acid, thiamin, riboflavin and niacin dissolve readily in water; consequently, as little water as possible should be used in preparation and cooking vegetables and meats, and water drained from the cooked product should be used in gravies, sauces or soups.

For maximum retention of nutritive value and vitamins, it is recommended that foods be stored at as low temperatures as practical for as long periods as possible.

Insects and Rodents in Shelter Stored Foods

Insects and rodents are problems where foods are exposed or the odor of foods prevails. These pests must be controlled in shelters, not only for the protection of foods, but clothing, furniture and humans as well. Since much of the damage is "hidden," thorough periodic inspections are necessary and orderliness is essential.

Five general methods of control are: (a) use of metal, glass or other protective packaging; (b) destroying existing pests by traps, fumigation or poisons; (c) prevention of entrance of pests from the outside; (d) avoiding places for breeding; and (e) elimination of supply of food available to pests.

Insects. There are myriads of kinds of household and food-loving flies, moths, beetles, wasps, roaches, spiders, fleas, crickets, ants and other insects that may inhabit food shelter pantries unless they are inhibited. These must be controlled because they spoil food, soil dishes, spread diseases, destroy labels and containers, and leave nauseating odors.

Methods of control of insects in foods in shelters, in order of importance, include the use of: (a) metal, glass or other protective packaging; (b) scrupulous cleanliness and sanitation; (c) temperatures of 48° or lower; (d) walk-in-type or other mechanical or electric traps; (e) special poison baits placed in selected places; and (f) irradiation of unprocessed foods, containers and certain equipment.

Specific kinds of insects require special means of control. For example, boring-type insects penetrate flexible packages unless protected by insecticides. Coating with pyrernone (10 parts piperonyl butoxide to one part pyrethrim insecticide--FDA okayed) is advised for outer surfaces and closures. Recommended coverage is five mg. pyrethins and 50 mg. piperonyl butoxide per sq. ft. After boring-type insects gain entrance others will follow.

Detailed directions for control of specific insects may be obtained from some of the references appearing in the appendix. In general, the best handling practices for the control of bacterial spoilage, molding, staleness and rancidity, will control insects.

Rodents. Rats and mice are trouble-makers in shelters, especially in cool, dark locations where runways, food and bedding are available. Unlike insects, rodents are active over a wide temperature range and may be destructive at as low as 0°. Since damage from rodents is much more extensive than that to foods alone, a thorough study of their control was not made.

Methods of control of rodents in foods in shelters, in order of importance, include the use of: (a) closely woven wire mesh storage bins; (b) metal, glass, or other rodent-proof packages; (c) cleanliness and orderliness, with the elimination of hiding places; (d) "run-in-type" traps; and (e) special poisons placed in selected locations.

The Availability of Processed Foods

Availability of foods which are known to have an adequate shelter life is a key concept to the CDM program as well as to the housewife who is planning to store foods in shelters. Knowing what foods are available and how long they will keep are essential for an effective and economical approach to buying and stocking food for shelter storages. Foods that are highly acceptable, flavorful and nutritious can be easily selected from the list of those available.

Following is an approximate order of availability of processed foods, based on the quantity commercially packed (references in Appendix). This information should be useful in making purchases, allotting space in shelters and in preparation of menus. A realistic program of food storage may be developed by selecting foods that appear in lists on pages 6 through 16.

All of these foods have qualities which make them valuable items for shelter storage. The canned soups, spaghetti meat products, meat stews, products with meat, and beef hash are almost complete meals in themselves; with the addition of a favorite vegetable and fruit juice drink a well balanced meal can be easily prepared which would not require the use of water or any

other preparation except opening of cans. The candy (hard candy in particular) would satisfy the desire for sweets and also quench thirst by keeping the mouth moist. Dried fruits could be eaten out of hand and would satisfy the hunger for sweets, particularly for those people whose intake of sugar must be limited. The dehydrated foods require the use of water or other liquid before they can be eaten, and that might prove a difficulty under shelter conditions.

Foods for Shelter Storage Listed in Approximate Order of Availability

Canned Meat and Meat Products

Soups
Meat products with less than 20 percent meat
Luncheon meats
Ham
Spaghetti meat products
Chili con carne
Products with 20 percent or more meat
Beef hash
Meat stew
Vienna sausage
Loins and picnics
Vinegar pickled meat products
Potted and deviled meat products
Hamburger
Tamales
Deviled ham
Chopped beef
Sausage in oil
Sausage
Tripe
Sliced dried beef
Brains
Tongue (not pickled)
Frankfurters and wieners in brine
Baby foods

Canned Fish and Fish Products

Tuna
Salmon
Sardines
Cod fish products
Mackerel
Shrimp
Crab and crab meat
Lobster
Clams
Oysters
Anchovies
Caviar
Baby foods

Canned Vegetables

Tomatoes
Peas
Catsup
Corn, cream style
Corn, whole grain
Snap beans
Sauer kraut
Sweet potatoes
Field peas
Lima beans
Tomato paste
Beets
Carrots
Spinach
Asparagus
Pumpkin
Chili sauce
Bean sprouts
Baby foods

Canned Fruits

Peaches
Pineapple
Fruit cocktail
Pears
Apples
Applesauce
Sour cherries
Cranberry sauce
Grapefruit
Plums
Sweet cherries
Blackberries
Figs
Apricots
Blueberries
Baby foods

Canned Juices

Tomato
Pineapple
Orange
Apple
Grapefruit
Grape
Grapefruit and orange
Baby foods

Canned Dairy Products

Evaporated milk
  unsweetened, unskimmed, skimmed
Condensed
  sweetened, unskimmed, skimmed
Whole milk, sterilized
Cheese, American processed
  processed

Canned Bakery Products

Date nut bread
Boston brown bread
Bread
Fruit cake
Pound cake
Pudding

Candy and Confectionery

Bar candy
  Chocolate covered
  Molded chocolate
  Confectionery (cocoa) coated
  Other bars
Packaged
  Less than 50¢ per pound
  Less than $1.00 per pound
  From $1.00 per pound to $2.00 or more
Other 5¢ and 10¢ specialties
Bulk goods
  Other bulk
  Chocolate covered
  Solid chocolate
  Confectionery (cocoa) covered
Penny candies

Dehydrated Foods

Dairy products
- Nonfat milk
- Dry whole milk
- Dried butter milk
- Whey
- Coffee-type cream
- Malted milk powder

Fruits
- Raisins
- Prunes
- Figs
- Dates
- Apricots
- Peaches
- Apples
- Pears

Baby foods

Fruit juices
- Citrus (orange, grapefruit, lemon)

Vegetables (approximate order)
- Potatoes
- Onions, garlic
- Pepper (cayenne, red, chili)
- Parsley

Sandwich Spreads

Canned cheese spread
Jams, jellies, preserves
Peanut butter

Need for Further Studies Concerning Food Storage

Throughout this study a few trends in our knowledge of food storage have stood out significantly, and it is recommended that future research continue in these general directions. A few additional areas of study are added.

More convenience foods. Studies on the trend toward more convenience foods should be continued. This includes more "heat-and eat" canned foods; "chill-and-serve" juices, fruits, salads and desserts; "add-water-only" dehydrated foods such as milk and milk products, fruit juices and pudding mixes; and "eat-from-the-package" confection-type foods. These foods are specially suitable for shelters in that little or no seasoning or cooking is required; serving may be by inexperienced personnel; a minimum amount of preparation equipment is required; and there should be no left-overs.

Better processing. Studies on the trend toward better processing of foods should be continued. This includes foods of high palatability and increased stability, because of more accurately controlled processing times and temperatures. Work in this area should be concentrated on canning and dehydration. More research is needed on high-temperature short-time canning, and on precooked freeze-drying of meats, vegetables, fruits and combination foods. There is special need for more research on methods of preparation and stability of low moisture (three percent or less) content foods.

More one-dish meals. More research is needed on the trend toward commercially precooked, seasoned and "portion-served" foods.

This includes the formulation of a wider variety of palatable, nutritious, one-dish meals--following the general procedure as used in the manufacture of animal foods. These meals should be highly acceptable and should supply the minimum daily requirement of carbohydrates, proteins, fats, minerals and vitamins. Many of the military rations approach this objective already.

Improve methods of serving. A study should be made of the best methods of preparing and serving foods in shelters of various sizes. This will include procedures for opening and disposing of containers, preparing and serving of food, disposing of garbage or left-over food, and handling special dietary problems.

Longer shelf life of precooked foods. Research on the stability of convenience foods, preseasoned, precooked, frozen-vacuum-dried, vacuum- and gas-packed, and very low moisture content foods should be continued.

Better flexible packages. Research on economical, flexible packages, which may be vacuumized and have a shelter life of two to five years at humidities above 70 percent and at temperatures of 80° or higher, should be continued. More should be known in regard to the suitability and stability of such packages for specific products, when stored at various temperatures and humidities.

Rustproof tin cans. Research on means of rustproofing tin cans, without excessively increasing the cost, should be continued. The "built-in" shelf life of tin cans should equal that of the most stable products and be economical for commercial use.

Rigid aluminum containers. Research on aluminum, as an alternate metal for rigid containers to withstand heat processing, should be continued.

Master containers. More information is needed on the development of "master containers" in which foods in smaller containers may be placed to protect them from rodents, insects, outside odors, and changes in air humidities. Questions to be answered are: What should be the size of master containers? What materials are to be used in construction? Are the containers reusable?

Control of insects and rodents. Since insects and rodents may be extremely damaging to foods, and since their control was not directly related to this study, it is suggested that a report on the overall insect and rodent problem be made.